OPERATION AND MAINTENANCE MANUAL

AILTECH
WAVEGUIDE NOISE GENERATOR

70 Series

EATON Advanced Electronics

Eaton Corporation
Electronic Instrumentation Division
Los Angeles, California 90066

58

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when operating AILTECH equipment.

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AILTECH
WAVEGUIDE NOISE GENERATOR

70 Series

PRINTED IN U.S.A.

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TABLE OF CONTENTS

		Page
I	Introduction	1-1
II	Specifications	2-1
III	Operating Instructions	3-1
IV	Noise Generator Calibration Service	4-1
V	Outline Dimensions	5-1
VI	Theory of Operation	6-1
VII	Maintenance	7-1
VIII	Factory Repair	8-1

LIST OF ILLUSTRATIONS

Figure		Page
1-1	AILTECH 70 Waveguide Noise Generators	1-1
5-1	Waveguide Noise Generator P/N 07049	5-1
5-2	Waveguide Noise Generator P/N 07050	5-1
5-3	Waveguide Noise Generator P/N 07051	5-2
5-4	Waveguide Noise Generator P/N 07052	5-2
5-5	Waveguide Noise Generator P/N 07091	5-3
5-6	Waveguide Noise Generator P/N 07053	5-3
5-7	Waveguide Noise Generator P/N 07096	5-4
6-1	Measured Noise Figure	6-3
6-2	Fired Insertion Loss Versus Reduction In Excess Noise Ratio	6-5
7-1	Removal of Noise Source Tube AILTECH P/N 113827	7-2
7-2	Removal of Noise Source Tube AILTECH P/N 116613	7-3
7-3	Removal of Noise Source Tube AILTECH P/N 206800	7-4
7-4	Removal of Noise Source Tube AILTECH P/N 118790	7-5
7-5	Removal of Noise Source Tube AILTECH P/N 114410	7-6

I. INTRODUCTION

The AILTECH 70 Waveguide Noise Generators are sections of standard waveguide housing argon-filled gas-discharge tubes (Figure 1-1). Except for the P/N 07096, each noise generator is supplied with a removable termination.

These assemblies provide a known amount of random noise uniformly distributed over the frequency range of each generator.

These units, together with auxiliary equipment, can be used to evaluate the noise performance of amplifiers, receivers, and receiver systems.

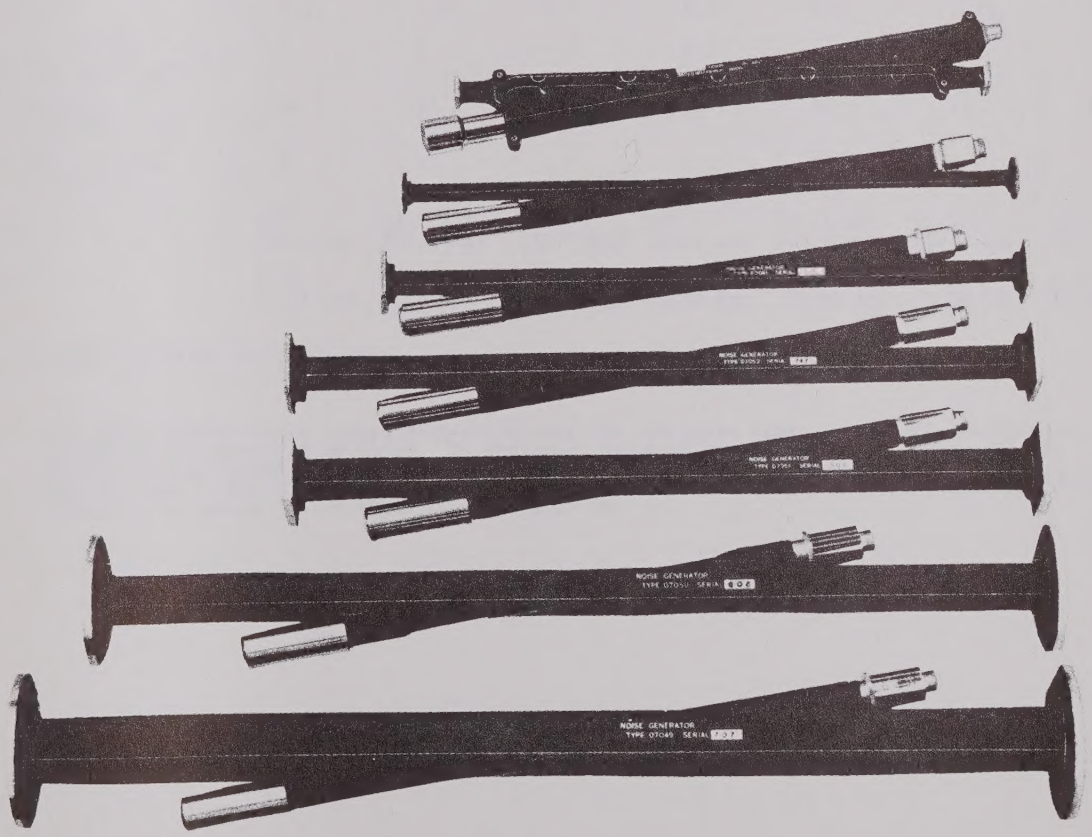

FIGURE 1-1. AILTECH 70 WAVEGUIDE NOISE GENERATORS

II. SPECIFICATIONS

Part Number*	07049	07050	07051	07052	07091	07053	07096
Frequency Range (GHz)	3.95-5.85	5.85-8.2	7.05-10.0	8.2-12.4	12.4-18.0	18.0-26.5	26.5-40.0
Excess Noise Ratio Tube Only (dB)	15.6	15.65	15.75	15.75	16.15	16.15	16.3
Anode Current (mA)	175	175	175	175	150	150	100
Noise Output Connections	UG-149A/U	UG-344/U	UG-51/U	UG-39/U	UG-419/U	UG-425/U	UG-599/U
Unfired SWR	1.3	1.3	1.3	1.3	1.3	1.35	1.3
Fired SWR	1.2	1.2	1.2	1.2	1.2	1.35	1.2
Maximum Unfired Insertion Loss (dB)	1	1	0.5	0.5	1	1	1
Minimum Fired Insertion Loss (dB)	12	15	12	20	12	15	15
Termination Power Rating (watts)	8	6	5	4	1.5	0.5	-
Length	24" (60.9 cm)	22-1/2" (57.1 cm)	18" (45.7 cm)	18" (45.7 cm)	15-11/16" (40.5 cm)	15-1/4" (38.7 cm)	13-1/2" (34.3 cm)
Weight	7 lb. (3.17 kg)	6 lb. 2.72 kg)	4 lb. (1.81 kg)	4 lb. (1.81 kg)	4 lb. (1.81 kg)	3 lb. (1.36 kg)	4 lb. (1.81 kg)

*Part number indicates waveguide size.

Note: The excess noise ratios listed herein are only for the noise tubes. The tube manufacturer's production tolerance is ±0.25 dB. To this must be added the comparison tolerance of his calibration equipment--typically, ±0.15 dB, and the uncertainty of the excess noise ratio of his National Bureau of Standards calibrated standard, ±0.1 dB. The absolute accuracy of the excess noise ratios listed then, is about ±0.5 dB.

III. OPERATING INSTRUCTIONS

The AILTECH 70 Waveguide Noise Generators can be operated with the AILTECH 71 Power Supply (Part No. 07111) or the AILTECH 75 Precision Automatic Noise Figure Indicator (Part No. 07511). Refer to the handbooks of the preceding instruments for instructions on connecting and operating the noise generators.

The excess noise ratio and operating current for each model are given in the specifications of Section II.

All AILTECH 70 Waveguide Noise Generators, with the exception of the P/N 07096, are provided with terminations. Before operating the 07096 it is necessary to connect one end to a termination with a SWR of less than 1.1.

For certain applications, it may be desirable to inject a test signal into the system under test through the noise generator. The internal terminations may be removed for this purpose. Simply remove the bolts holding the termination flange to the noise generator and remove the termination. The signal generator connected to the unused flange should exhibit a SWR of less than 1.1 when it is turned off.

The terminations should be stored with some care when not in use. These devices are somewhat fragile and can be damaged quite easily through mishandling.

All AILTECH 70 Waveguide Noise Generators except P/N 07096 are shipped with the noise tube in a separate container for additional protection during shipment. Before operating, follow the instructions in Section VII for your particular type of tube.

IV. NOISE GENERATOR CALIBRATION SERVICE

AILTECH now offers a calibration service for noise generators with results directly traceable to the National Bureau of Standards.

Noise parameter measurements are usually based on the noise source manufacturer's specification of excess noise ratio and some theoretical considerations. The resulting uncertainties can easily exceed ±0.5 dB. This uncertainty can now be reduced to as low as ±0.11 dB in the microwave band up to 18 GHz.

The measurement system used is the AILTECH 82 Microwave Noise Temperature Calibration System. This instrumentation was developed at AILTECH and evaluated by the National Bureau of Standards (NBS). The NBS evaluation has shown that the comparison accuracy of the system is better than ±0.05 dB. Coupled with the uncertainty of ±0.06 dB of the NBS calibrated noise standard, this results in an overall attainable accuracy of ±0.11 dB at specific frequencies traceable to an absolute standard.

Contact your local AILTECH sales office for specific information and prices for this new service.

V. OUTLINE DIMENSIONS

Figures 5-1 through 5-7 give the dimensions in inches of the AILTECH 70 Waveguide Noise Generators.

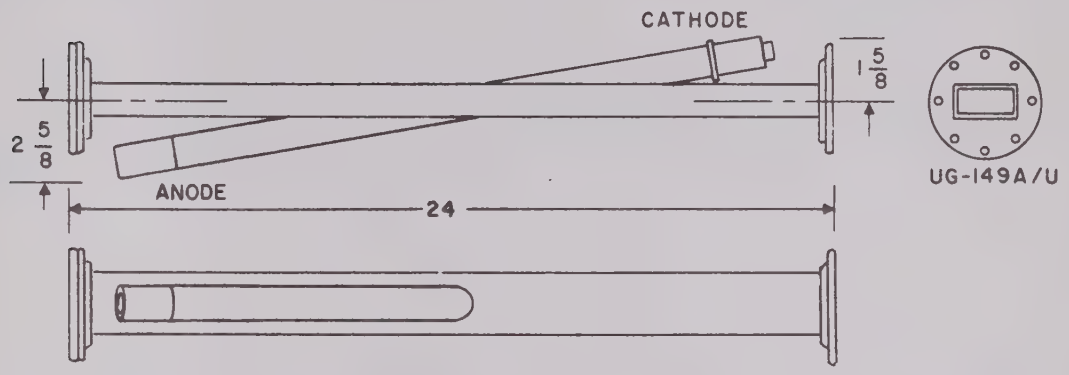

FIGURE 5-1. WAVEGUIDE NOISE GENERATOR P/N 07049

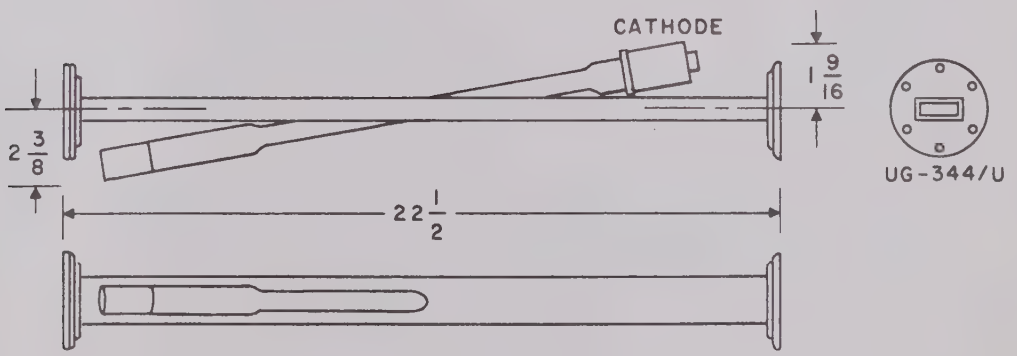

FIGURE 5-2. WAVEGUIDE NOISE GENERATOR P/N 07050

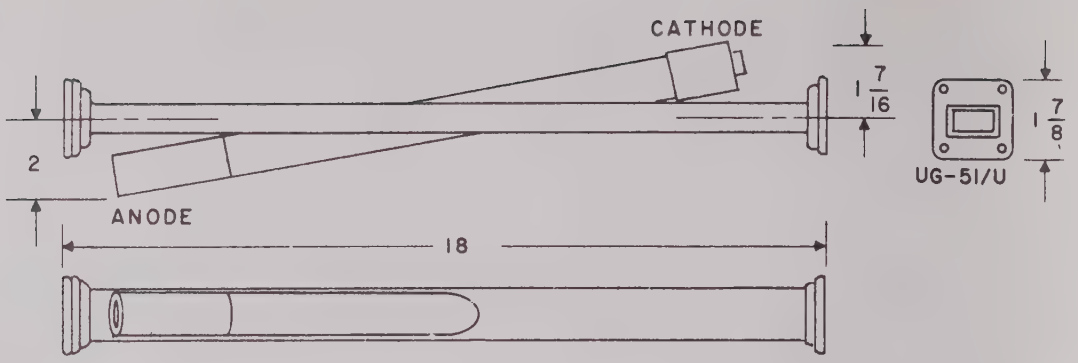

FIGURE 5-3. WAVEGUIDE NOISE GENERATOR P/N 07051

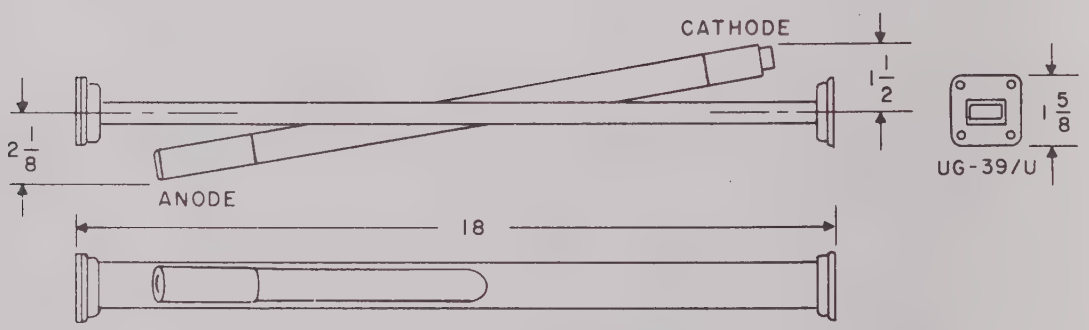

FIGURE 5-4. WAVEGUIDE NOISE GENERATOR P/N 07052

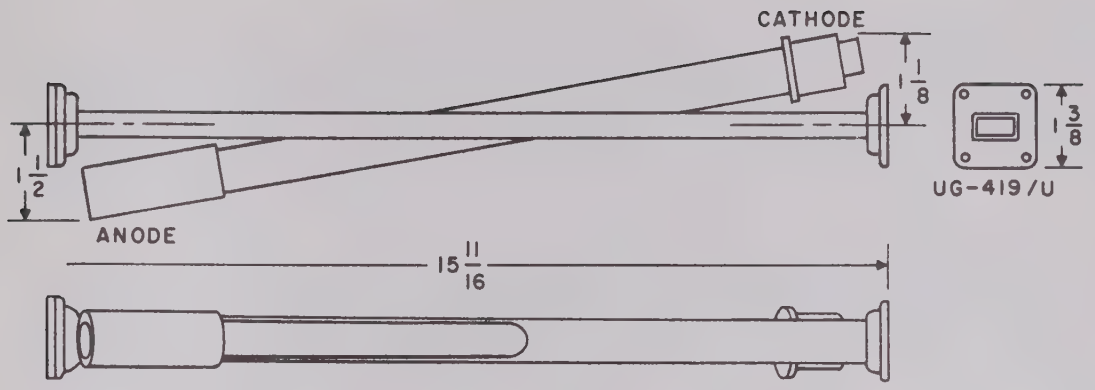

FIGURE 5-5. WAVEGUIDE NOISE GENERATOR P/N 07091

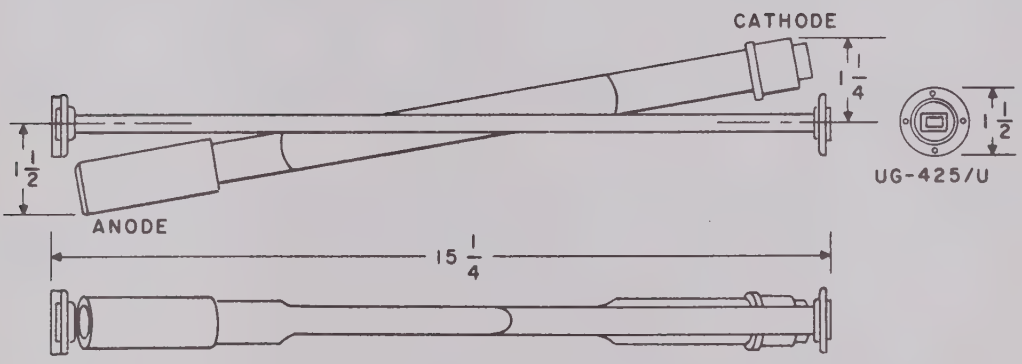

FIGURE 5-6. WAVEGUIDE NOISE GENERATOR P/N 07053

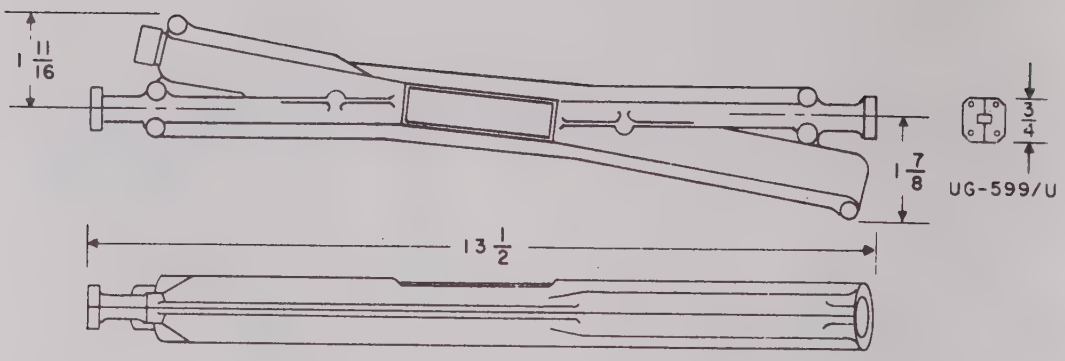

FIGURE 5-7. WAVEGUIDE NOISE GENERATOR P/N 07096

VI. THEORY OF OPERATION

Waveguide Noise Generators make use of the positive column of a gaseous discharge as a broadband untuned resistive termination for a waveguide. If the insertion angle of the gas discharge tube is small, there is very little reflection from the discharge. The minimum insertion angle is determined from the additional consideration that, as insertion angle decreases, reflections due to the cutaway guide walls increase.

Performance is optimized by locating the discharge tube in the E-plane, entering the waveguide through the broad faces. Hence, the greatest linear dimension of the cutaway portion of the guide wall is parallel to the current flow in the wall. This leads to a minimum reflection when the discharge is turned off. Thus, transmission through the waveguide section containing the discharge tube is accomplished with negligible loss.

The noise temperature (T_2) of the gas discharge tube is virtually independent of ambient temperature. A variation of discharge current of the order of ±20 percent of peak value will produce an average change of excess noise ratio of only -0.003 dB/mA.

AILTECH 70 Waveguide Noise Generators can be used in any of the standard setups for performing noise-figure measurements of receivers in the 3.95 to 40 GHz range. Basically, these methods involve the measurement of the Y-factor, which is defined as the ratio of the noise output power of the receiver with the noise generator on to that with the noise generator off.

The general formula for deriving the noise figure (F) of a microwave receiver (using a gas-discharge type noise source) is shown in equation 1.

$$F = \frac{\left(\frac{T_2}{T_o} - 1 \quad - Y \frac{T_1}{T_o} - 1\right)}{Y - 1} \qquad (1)$$

where

T_2 = electron temperature of the discharge in Kelvins (generator "on"),

T_1 = temperature of the termination in Kelvins (generator "off"),

T_o = 290 K,

Y = ratio of the noise output power of the receiver with the noise generator on, to that with the noise generator off.

In most practical cases, $T_1/T_o \approx 1$, so that equation 1 reduces to:

$$F = \frac{\left(\frac{T_2}{T_o} - 1\right)}{Y - 1} \qquad (2)$$

$$F_{dB} = 10 \log \left(\frac{T_2}{T_o} - 1\right) - 10 \log (Y - 1)$$

Instead of actual computation, noise figure can be determined from Figure 6-1 if the excess noise ratio (T_{ex}) of the noise source (Section II) is equal to one of the values shown in Figure 6-1. Excess noise ratio is defined in equation 3.

$$T_{ex} = \frac{T_2}{T_o} - 1 \qquad (3)$$

$$T_{ex}\,dB = 10 \log \left(\frac{T_2}{T_o} - 1\right)$$

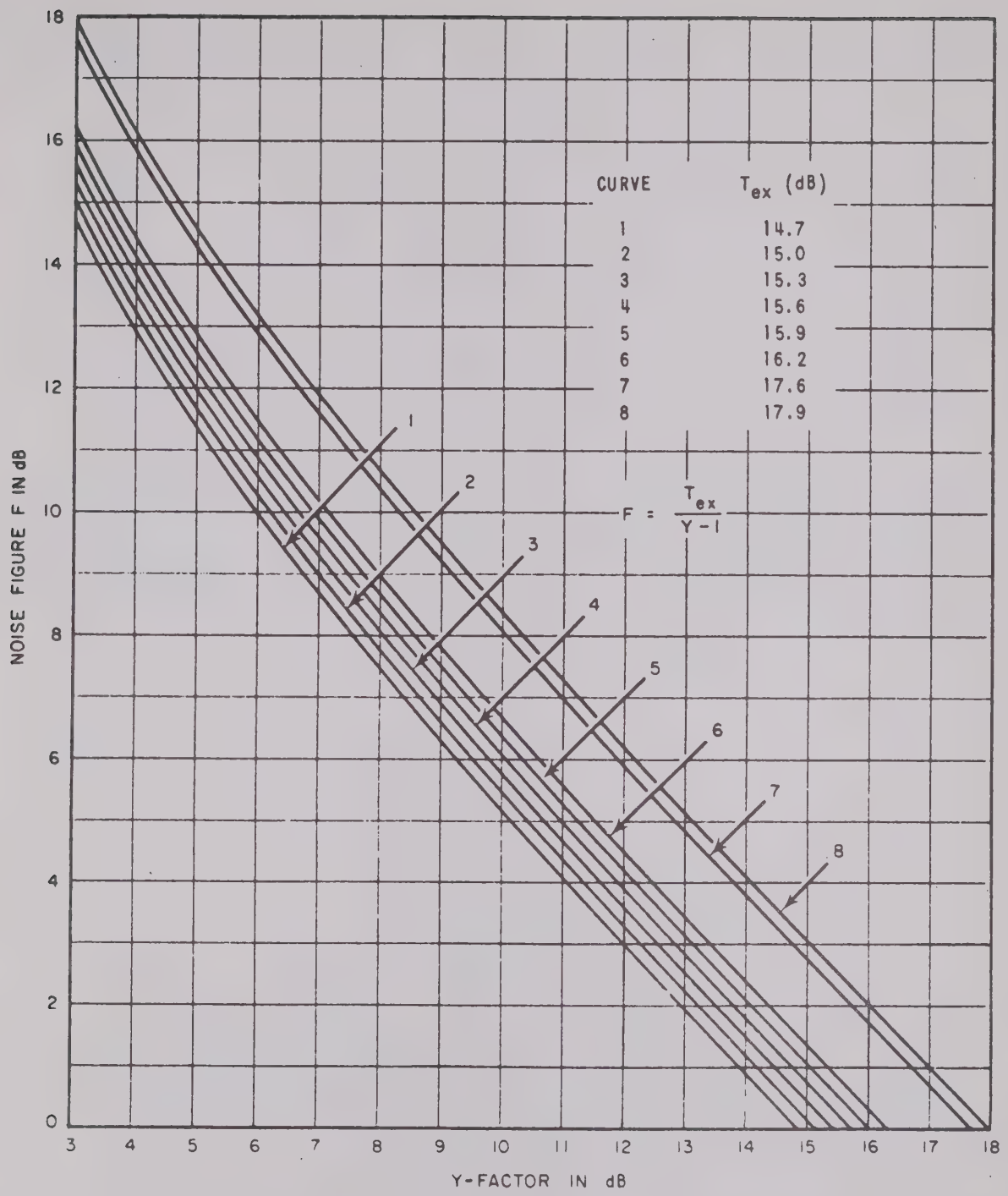

FIGURE 6-1. MEASURED NOISE FIGURE

If the excess noise ratio of the noise source is other than one of the values shown in Figure 6-1, noise figure can be determined as follows:

1. Determine noise figure from the graph (Figure 6-1), assuming $T_{ex} = 15.3$ dB.

2. The correct noise figure is determined from

$$F_{actual} = F_{graph} + T_{ex} - 15.3 \text{ dB} \qquad (4)$$

Alternatively, the AILTECH Noise Figure Slide Rule, which makes provision for a spread in excess noise ratio, can be used to perform the calculation.

This discussion assumes that the effective temperature of the generator in the on condition is equal to that of the discharge. This is true if the coupling to the discharge is complete. If this is not the case, there is a reduction in the output noise. A measure of this coupling is the insertion loss of the generator in the fired condition. This loss is easily measured and provides the best means of computing this correction.

The expression for this reduction is

$$\frac{T'_{ex}}{T_{ex}} = 1 - \frac{1}{L_H} \qquad (5)$$

where

T'_{ex} = excess noise ratio of the generator

T_{ex} = excess noise ratio of the noise tube

L_H = hot insertion loss of the generator = $\frac{P_{in}}{P_{out}}$

This expression is plotted in Figure 6-2 as the dB reduction in excess noise ratio as a function of L_H in dB. This value should be subtracted from the noise figure given in equation 4.

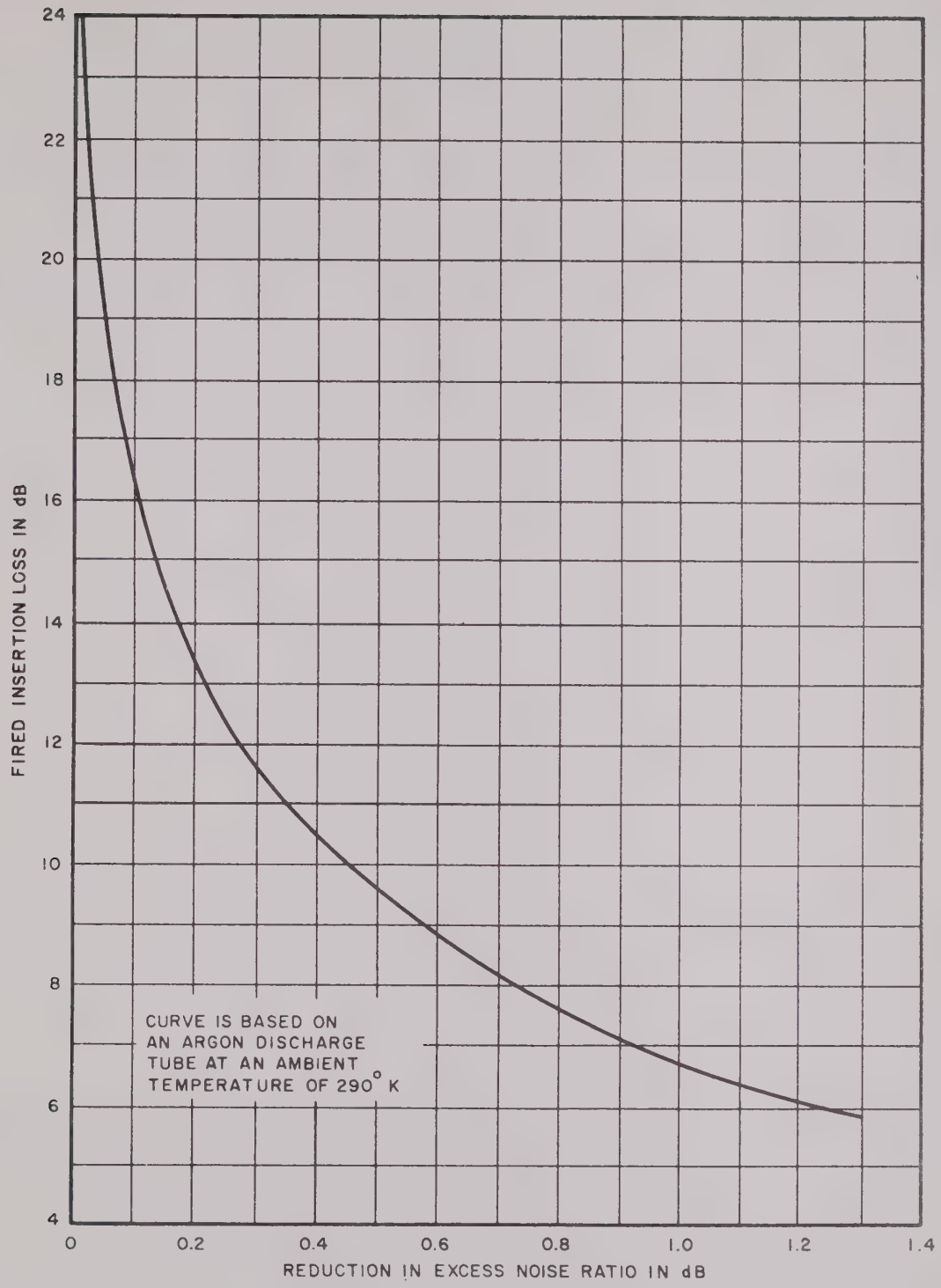

FIGURE 6-2. FIRED INSERTION LOSS VERSUS REDUCTION IN EXCESS NOISE RATIO

VII. MAINTENANCE

If the tube on the AILTECH 70 Waveguide Noise Generator does not fire, it should be replaced.

The procedure for removing the tube varies with the different types of generators. Detailed removal instructions for generator and replacement parts list follow. See Figures 7-1 through 7-5.

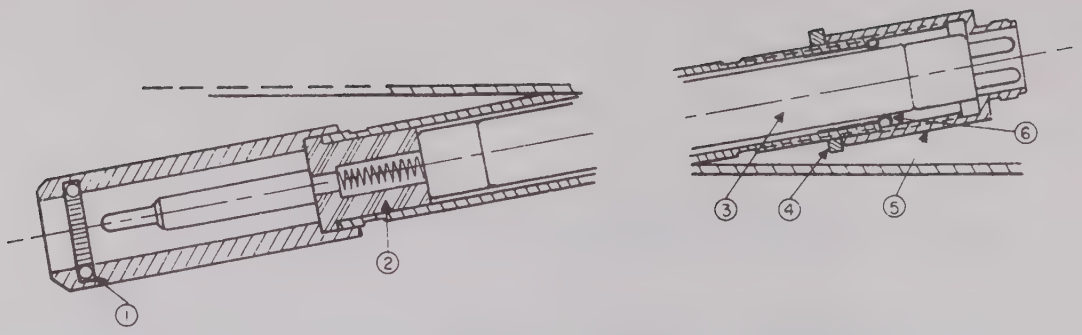

FIGURE 7-1. REMOVAL OF NOISE SOURCE TUBE AILTECH P/N 113827

SPARE PARTS

Symbol	Description	AILTECH Part No.
1	SPRING	113974
2	ANODE CONTACT ASSEMBLY	116826
3	TUBE, NOISE SOURCE	113827
4	LOCKNUT	116829
5	CATHODE CONNECTOR	116830
6	CONTACT STRIP	116831
	TERMINATION	207295-2

PROCEDURE

To remove Noise Source Tube P/N 113827, proceed as follows:

1. Loosen locknut (4).
2. Unscrew cathode connector housing (5).
3. Remove tube (3) by withdrawing from generator.
4. Contact strip (6) may come out with tube. Replace as shown.
5. Insert replacement tube and assemble in reverse order.

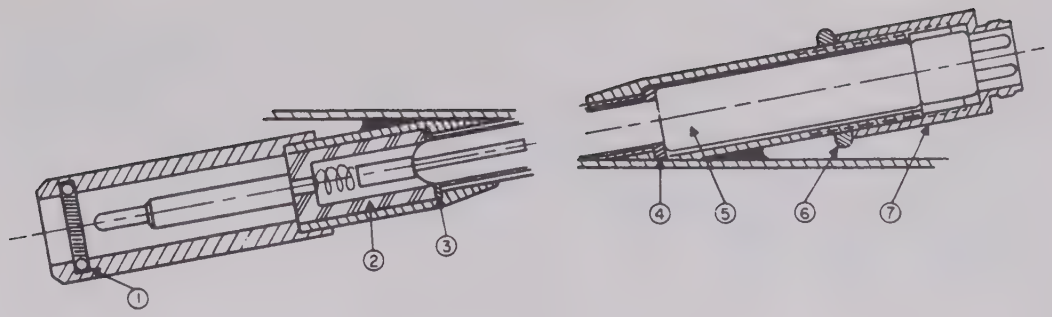

FIGURE 7-2. REMOVAL OF NOISE SOURCE TUBE AILTECH P/N 116613

SPARE PARTS

Symbol	Description	AILTECH Part No.
1	SPRING	113974
2	ANODE CONTACT ASSEMBLY	116610
3, 4	SPACER	116611
5	TUBE, NOISE SOURCE	116613
6	LOCKNUT	116829
7	CATHODE CONNECTOR	116830
	TERMINATION	207295-3

PROCEDURE

To remove Noise Source Tube P/N 116613, proceed as follows:

1. Loosen lock ring (6).
2. Unscrew cathode connector housing (7).
3. Remove tube (5) by withdrawing from generator.
4. Replace spacer (4) as shown.
5. Insert replacement tube and assemble in reverse order.

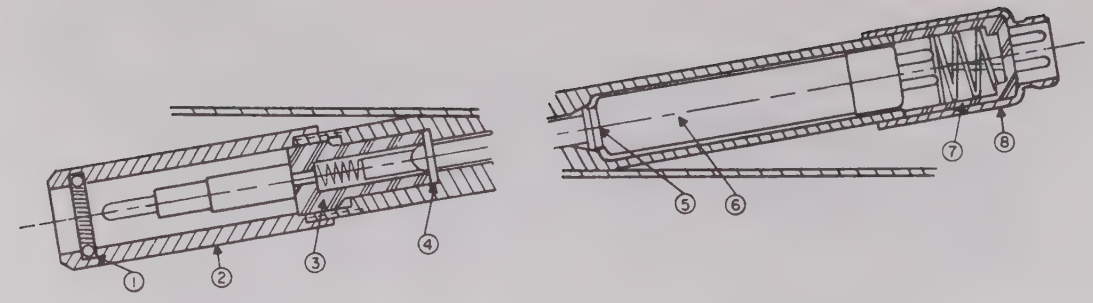

FIGURE 7-3. REMOVAL OF NOISE SOURCE TUBE AILTECH P/N 206800

SPARE PARTS

Symbol	Description	AILTECH Part No.
1	SPRING	113974
2	ANODE SLEEVE	116840
3	ANODE CONTACT ASSEMBLY	116837
4	SPACER	116841
5	O-RING	MS 28775-010
6	TUBE, NOISE SOURCE	206800
7	CONTACT ASSEMBLY	206869
8	FILAMENT CONNECTOR	207189
	TERMINATION FOR 7051	207295-4
	TERMINATION FOR 7052	207295-5

PROCEDURE

To remove Noise Source Tube P/N 206800, proceed as follows:

1. Remove filament connector ring (8).
2. Remove contact assembly (7).
3. Remove tube (6) by withdrawing from generator.
4. Put O-rings (5) on new tube.
5. Insert tube and assemble in reverse order.

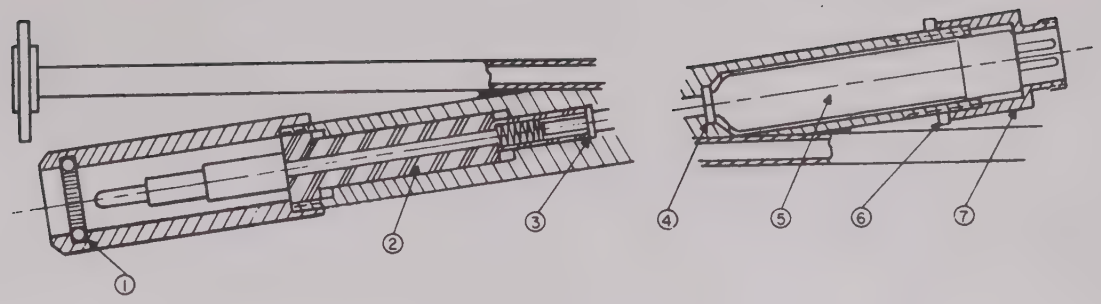

FIGURE 7-4. REMOVAL OF NOISE SOURCE TUBE AILTECH P/N 118790

SPARE PARTS

Symbol	Description	AILTECH Part No.
1	SPRING	113974
2	ANODE CONTACT ASSEMBLY	118789
3	ANODE SPACER	118792-1
4	CATHODE SPACER	118792-2
5	TUBE, NOISE SOURCE	118790
6	LOCKNUT	116829
7	CATHODE CONNECTOR	118781
8	ANODE SLEEVE	116840
	TERMINATION FOR 7053	207295-7
	TERMINATION FOR 7091	207295-6

PROCEDURE

To remove Noise Source Tube P/N 118790, proceed as follows:

1. Loosen lock ring (6).
2. Unscrew cathode connector housing (7).
3. Remove tube (5) by withdrawing from generator.
4. Replace spacer (4) as shown.
5. Insert replacement tube and assemble in reverse order.

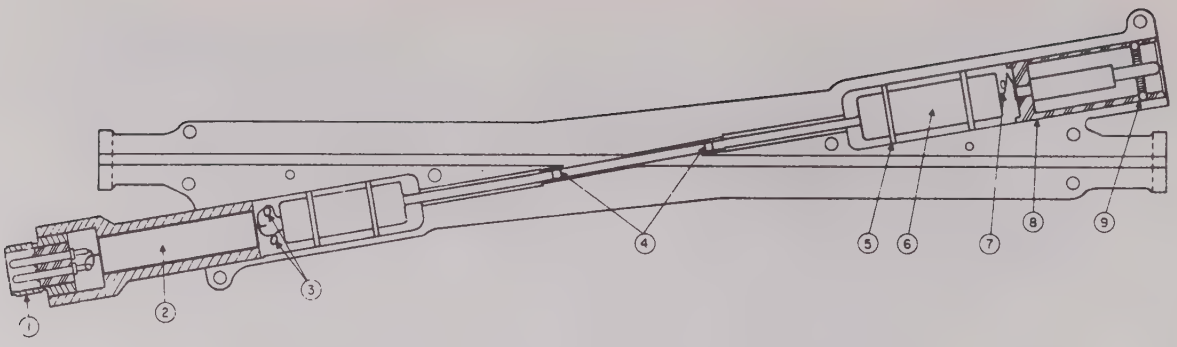

FIGURE 7-5. REMOVAL OF NOISE SOURCE TUBE AILTECH P/N 114410

SPARE PARTS

Symbol	Description	AILTECH Part No.
1	CATHODE CONTACT ASSEMBLY	113653
2	RESISTOR	206917-1
4	PAD (4)	114442
5	WASHER (4)	114439
6	TUBE, NOISE SOURCE	114410
8	ANODE CONNECTOR	114441
9	SPRING	113974

PROCEDURE

To remove Noise Source Tube P/N 114410, proceed as follows:

1. Remove all screws on top of unit.

NOTE

It is important to avoid marring the internal waveguide surfaces or the mating surfaces. A suggested method of separating the two halves of the generator is to use wooden or plastic wedges that fit in the waveguide ends. Gently pry both halves apart, keeping the mating surfaces parallel. This will expose the tube for replacement.

2. On the bottom of the upper mount are two small teflon pads (4). These pads are held in place with a small amount of silicone grease and may adhere to the noise tube (5). These pads should be removed and saved for reassembly.

3. Unsolder the flexible leads (3, 7) from the tube pins and remove the tube from the lower half of the mount. Locate the two additional teflon pads and save them. Also save the flexible leads and four silicone rubber washers (5).

NOTE

The replacement tube mentioned in the following procedure is delicate and expensive. Use utmost care and caution in handling.

4. The replaced tube is installed as follows:

   a. Scrape terminals at both ends of the tube as close as possible to the glass seal to facilitate soldering.

   b. Snip off terminals leaving about 3/16 inch projecting from the end of the tube (both ends).

   c. Tin the terminals and bend back into the recess at the end of the tube (both ends).

   d. Soft solder the flexible leads to the tube terminals, avoiding excessive heat. The cathode end has two terminals that should be shorted together.

   e. Place the silicone rubber spacer washers on the bulbous ends of the tube. The notches on the washers should be located on the tube to align with the mating surfaces of the mount.

   f. If the mount is dirty, clean it with isopropyl alcohol and dry with compressed air.

   g. Replace the four small teflon pads in the mount. (Hold in place with small amount of silicone grease if required.)

h. Place tube into lower mount assembly and solder pigtail ends of tube to connector and resistor.

i. Align hardware and components on the lower half of the mount in their proper positions. (Set screws should fit into detents of the connector housings.)

j. Dress flexible leads so that they do not touch side walls of the mount.

k. Place upper half mount on lower half assembly and gently but firmly press the upper mount down, keeping both halves parallel.

5. Insert screws and fasten castings tightly together.

VIII. FACTORY REPAIR

If the equipment is to be returned to the manufacturer for repair, please return it in accordance with the following instructions.

1. Write to AILTECH, West Coast Operation, giving complete information concerning the failure and the manner in which the equipment was being used when failure occurred. Include the unit type and serial numbers.

2. Special shipping instructions will be supplied by AILTECH. When the shipping instructions are received, pack and ship the equipment as directed. Transportation charges should be prepaid and a failure report should be supplied with the equipment.

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